Scope of SCWA proposal for estimating upland stream flow in the Russian River watershed

Approach to the Project

The Sonoma County Water Agency is dedicated to salmon recovery in the Russian River Basin. As part of this goal it is important to address existing and additional demand for water in the Russian River Basin so that water management will not reduce fish survivorship and recovery. This effort has involved working with the State Water Resource Control Board, resource agencies, and stakeholders in the Russian River Basin. In support of this effort, this scope of work is designed to better quantify upland tributary flows, and to assess the impacts of currently existing water rights and demand associated with upland agriculture to stream flow, instream function and riparian habitat function. The information provided is intended to assist in assessing the extent to which additional surface water abstractions can be supported relative to the needs of previously established instream values and assist restoration efforts where water quantity may be limiting salmon recovery.

Compiling additional information on stream water availability, local demand for water, and the causal relationships between different water management alternatives and stream flow in a user friendly framework is an important first step in the process. The type of additional data and analysis outlined in this scope is needed to base changes in policy and practice on because the existing data does not satisfactorily express stream flow conditions over scales relative to human and ecological needs. In fact, stream flow data in Russian River tributaries are a key type of data not adequately described among existing data sets for making water rights assessments. The US Geological Survey (USGS) has historically measured stream flow only in a select number of streams; those gauge locations are not representative of the locations where water rights are increasingly requested. USGS gauges are commonly on large tributaries or in urban areas (Deitch 2006), whereas requests for water rights are increasingly in smaller drainages along headwater streams (SWRCB 1997). Hydrological theorists speculate that, because of differing hydrologic processes governing runoff, flow in small streams may not be described simply by linear scaling according to data collected downstream (Gupta and Mesa 1988) or modeled without some data from smaller streams to make accurate comparisons (Hopmans and Pasternak 2006, Sivapalan 2003). This disparity between where flow has been measured and where water rights are requested has been documented as one of the primary limitations to water rights decisionmaking in the Russian River catchment (Moyle and Kondolf 2000).

Also, the impacts of different water management strategies used in the upland tributaries of the Russian River for vineyard management are not well understood. The tasks presented in this scope of work are designed to provide initial data and methods for analyzing upland stream flows and the consequences of agricultural water use.

Ultimately, this type of information will provide spatially explicit models that will quantify the tradeoffs for both the wine grape growers and salmonid recovery efforts between storing more water in the winter and pumping on demand year round to meet agricultural and residential water needs.

Project Tasks

The primary objective of this work will be to better quantify upland tributary flows within the Russian River Basin. We will first identify sub-basins within the Russian River Basin where existing and proposed rights that supply water to agriculture and rural residential development during the dry season may exceed supply and where alterations in the way that water is managed could lead to salmonid recovery. The latter involves integrating spatial information describing habitat, current and historical salmonid populations, land use, and existing diversions as well as storages. Then we will collect new stream flow data and, where possible, match with existing tributary flow and precipitation data to measure (and, where possible, model) seasonal tributary flows over ecologically significant timescales. Information on upland tributary flows in relation to rainfall provides critical information on water availability that can later be compared to the current and forecasted demand for water use throughout the year. In addition, field data will be collected to characterize water levels across spawning gravels and in pool habitat during the dry season at selected sites in order to relate stream flow with environmental flow requirements for salmonids. We will also attempt to use existing GIS data to address the specific concern for water management decision-making of how distributed small off-stream storage impacts winter adult salmonid bypass through upland tributaries in the winter. This is an important task given the demand for increased rights to store winter runoff to use during the dry season, which has the benefit of reducing direct demand for water during the dry season. The tasks outlined below will help us achieve these goals.

Task 1 – Site selection (First month)
Streams and study sites will be prioritized based on basin size; existing hydrological, biological, and habitat information; demand for water relative to likely supply; options for changes to water management; and need for conflict resolution, with input from water agency and other local experts. Taking advantage of existing work means that the following streams will be included: Franz, Maacama, Mark West, Santa Rosa, Sausal, and Green Valley. Additionally, other upland tributaries into Knights, Alexander, and Dry Creek will be a high priority. Priority will be given to areas where there is empirical data available or where similarities exist between well-studied watersheds and watersheds of concern.

Task 2 – Augmenting flow data in upland tributaries (Over the two-year funding period)
To increase our empirical understanding of upland tributary flows, we will collect new data along selected streams and at upper and lower points in their watersheds. Actual

stream flow data are important because they depict stream flow fluctuations over appropriate time scales: the magnitudes, durations, frequencies, and timing of stream flow that characterize streams' natural flow regime describe water availability for human and ecological needs at the temporal scales over which flow varies (Poff et al. 1997, Richter et al 2003). Stream flow data quantify the requisite conditions for important ecological functions, such as flushing flows to maintain appropriate spawning sediment distributions, bypass flows to allow adult salmonids to migrate to suitable spawning locations, and spring/summer base flows to provide conditions for egg incubation and juvenile rearing. Stream flow data also provide the foundation for water rights assessments at appropriate temporal scales: expressions of water demand (i.e., how users divert water from the stream; Deitch 2006) can be compared to stream flow to evaluate how methods of diversion would affect stream flow or whether users could expect to get needed waters under the restrictions placed by Water Board limitations. Data described at more coarse scales, such as monthly or even daily, cannot accurately depict the variations in flow that control the occurrence of instream processes (Deitch 2006).

Our gauge design will be closely connected with available stream flow data sets (i.e., historical USGS data) to address variations in stream flow across space and time relative to existing data sources. We will focus on measuring stream flow in small streams, such as those which the Water Board has suggested are under increasing pressures for water rights: first- through third-order tributaries draining catchments ranging from 1 to 15 mi^2 (SWRCB 1997). Such headwater streams provide important ecological functions, including spawning and rearing habitat for anadromous salmonids such as coho salmon and steelhead trout and are increasingly subject to pressures for many other beneficial uses. By establishing upland stream flow gauges in proximity to historical and existing stream flow sites, our data can also improve current methods for forecasting stream flow at proposed diversion locations elsewhere in the drainage network, and as appropriate, develop more accurate methods than those currently suggested in water rights protocols (Task 3).

Task 3 – Modeling and mapping tributary hydrographs (First set of watersheds in first year followed by more the second year.)

In addition to providing accurate depictions of stream flow at ecologically meaningful scales of space and time, stream flow collected in Task 2 can be used for two modeling efforts. First, both precipitation and historical and recently collected stream flow data will be used to derive and test statistical models of stream flow as a function of recent rainfall using a multiple regression analysis. Flow can be expressed as a function of rainfall over antecedent periods such as the previous 3 days (illustrating the extent to which flow may be affected by a storm), the previous 14 days (illustrating the influence of rainfall over a biweekly scale), or the previous 90 days (showing the potential effects of seasonal trends in rainfall). The regression equations derived from historical stream flow and rainfall data can be used to estimate stream flow during previous salmonid

assessments, when only rainfall was measured, and to project stream flow given rainfall data in the future.

Second, we will use our measured stream flow data to improve upon current scaling techniques for extrapolating stream flow to other locations in a drainage network. The Water Board currently advises water rights applicants to estimate discharge at a proposed diversion site according to a ratio of drainage basin size so that the discharge at an upstream site is equal to discharge measured at a downstream or nearby historical USGS gauge, scaled according to catchment area (i.e., assuming that differences in flow in a stream is related to drainage basin size; SWRCB 2001). Recently collected data indicate that this scaling assumption may not always be valid: peak flows tend to be proportionally higher and base flows tend to be proportionally lower in smaller streams than larger ones, and discharge over broader timescales is not simply proportional upstream to downstream (Deitch 2006). Using our collected flow data, we will adjust scaling models to more accurately depict instream conditions through the year (see Task 3). Established USGS gauges on Santa Rosa and Mark West Creeks can serve as foundations for measuring and predicting flows in these sub-basins.

We will compare our predicted stream flows to measured stream flows at each of the sites during the course of the proposed work to further test our modeled stream flow, recognizing that land use conversions that have occurred since historical stream flow records were collected could have altered the previous relationship.

Task 4 – Seasonal changes in water availability in salmonid habitat (Completed by the end of the two-year study)

In a select number of reaches where flows will be measured (Task 2), we will collect high-resolution information describing seasonal habitat conditions for steelhead populations in upland tributary streams. This stream habitat monitoring will focus on measuring changes in water levels across riffles and pools to determine the magnitude and duration of specific environmental flows relative to the anadromous salmonid life cycle (i.e., those flow conditions required to maintain specific ecological processes such as spawning and upstream adult bypass in winter, redd incubation in winter and spring, and downstream energy drift in spring and summer) and will also include an assessment of physical habitat variables along each reach, including riparian vegetation cover, channel morphology, streambed substrate, and habitat structure (e.g. large woody debris, boulders, and undercut banks) that can influence water levels at the site scale. We will identify and map individual habitat units along the reach pursuant to Department of Fish and Game salmonid habitat-typing protocols and measure the water and air temperatures, since the former influences fish survivorship and the latter can trigger higher-intensity of water use for frost and heat protection for vineyards.

Task 5 – Winter water storage impacts on peak winter flows. (Pilot watersheds completed in first year. Comparison with alternative management scenarios the second year)

Conservation interest groups and resource agencies are concerned that the increasing number of small surface water reservoirs in headwater Russian River tributaries may have significant impacts on downstream flows required for ecological processes (Trout Unlimited/Audubon 2004). We would like to use our collected flow data along with existing GIS resources to evaluate the local and cumulative catchment-scale impacts of small reservoirs on stream flow in Russian River tributaries. Much of the preliminary GIS work for this task has already been conducted: in recent research, we used aerial photographs of Sonoma and Mendocino Counties to trace all small storage reservoirs onto a GIS, and used existing water rights and DWR records (and where necessary, extrapolations according to reservoir surface area) to quantify the volume of storage capacity for each reservoir. We plan to estimate stream flow into each reservoir and the duration of time before reservoirs fill and begin spilling water into the channel below using relationships derived from the data we collect in headwater tributaries and quantify flow lost from the downstream discharge as a result of the reservoirs filling. The GIS will give us the spatial foundation to evaluate the local and cumulative effects of several reservoirs in the basin on flows in streams that salmonids may use as freshwater habitat. This will be done for a select number of watersheds to demonstrate the utility of this approach.

Additional contributions

I. Technical applications and advice

Dr. Adina Merenlender and her research team will be available for consultation with water agency scientists and other contractors working on water rights accounting. This will include consultation with David Newburn, who is a resource economist working on optimization of storage capacity in Russian River tributaries to assist with trade-off analyses.

II. Outreach

We welcome the opportunity to discuss this research and any results with resource professionals, state and county agency staff, and the general public.

Qualifications

Our research and extension group was developed by the University's Integrated Hardwood Range Management Program to apply science based decision making tools to landscape level land-use analysis and planning. We are located at a University Research and Extension Center in southern Mendocino County to improve access to our expertise and facilities by the public and private sectors in California's north coast. At this location we have developed a complete GIS laboratory and focused our efforts on accumulating GIS data layers for the physical landscape, natural resources, agriculture, and land-use such as urban areas in Sonoma County. This information is currently being used for research and extension purposes focused on land-use change, planning, and policy development.

As principle investigator, Dr. Adina Merenlender will oversee all activities associated with this project. She has a Ph.D. in biology and her background is in conservation science with extensive experience in science based policy making. As a faculty member at UC Berkeley, she is expected to publish in the scientific literature and as a member of the UC Cooperative Extension she also writes educational materials designed for the general public. This work has resulted in over 50 published articles. This combination of scientific training and practice along with extensive extension activities in the public arena make her well qualified to write clearly, explain complex issues to the general public, and communicate with a diverse audience.

The GIS analyst, Shane Ferier, who works in our group has extensive experience and is well qualified for the type of work required to complete this project. Matt Deitch is currently finishing his Ph.D. in watershed hydrology with Professor G. Matt Kondolf and will be working on the project as an ecohydrologist. Matt's research has focused on stream flow variations in Russian River tributaries, and he will take the lead on modeling hydrographs as well as supervise field measurements. Ted Grantham is working on his PhD on upland tributary salmonid habitat and its relation to season flow regimes. Ted will conduct the fish habitat field work. David Newburn is an Assistant Professor at Texas A&M in agricultural economics and will be available for consultation on future ways to assess tradeoffs associated with management decision making. We may also hire additional field assistants to meet the stated objectives.

Project Budget

See attached spread sheet.

Reporting timeline

One annual report will be submitted 12 months after the contract start date and a final report will be submitted with in 90 days after the contract closing date.

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